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In order to achieve uniformity of presentation, all contributions have been more or less revised by the editors.

Wilhelm Walcher

Theory and Practice of Vacuum Technology

With 424 figures and 85 tables

Friedr. Vieweg & Sohn Braunschweig / Wiesbaden

Translated by *W. Steckelmacher*

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This book is the English translation of the fourth (1988) Edition of the Germ „Theorie und Praxis der Vakuumtechnik". The need for an English version to be also arose as soon as it became evident (e.g. from sales figures) that the comprehensive the subject – which has proved to fulfil so accurately current needs – was well internationally by scientists and engineers working in the field. As a result the book became the standard work of reference.

As already stated in the first German edition the aim of this book is to present prehensively as possible the field of vacuum technology in the production of vac measurement and the maintaining of low pressures and related methods.

This book is directed to all those who are dealing with experiments, processes ar work where vacuum is involved. Theoretical principles and practical requirements are in equal depth. This is well supported by a large number of numerical examples, an though very helpful feature.

In the course of time diversification and specialization in the various areas have becor and more pronounced. It seemed only appropriate to relay upon the knowledge of sp in their particular fields, then to integrate their contributions into the whole.

It has been the aim of the editors to adapt the symbols, units and nomenclature to tl national and national recommendations (IUPAP). Chapter 16D covers quantities an also includes conversion tables and numerous references. This will result in smooth tr to use of the new units and nomenclature.

Comprehensive references have been added at the end of each chapter augmen numerous references in English. A separate chapter with tables and diagrams will h user to find quickly important data and simplify his calculations. A comprehensive t international and national vacuum standards meets present day requirements in tl something which is equally important to both manufacturers and users.

It is hoped that this book will contribute to the further development of the still sig and interesting science of "vacuum" and its increasing number of applications in scier technology.

Cologne, February 1989

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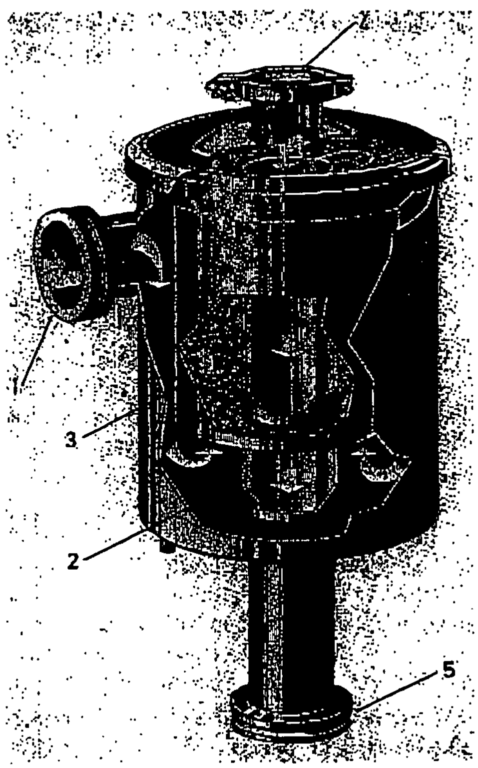

Fig. 5.36 Dust filter
1 connection flange to vacuum system;
2 cyclon-separator;
3 oil soaked fine separator;
4 and 5 pump connections (by choice); small flange and clamp flange respectively (as examples).

5.4 Roots pumps

This type of pump has long been available. In 1848 an Englishman "Isaiah Davies" invented a pump, the construction principles of which were taken over some 20 years later by the Americans "Francis M and Philander H Roots" and have become known as "Roots blowers". Since that time Roots pumps have found a variety of technological applications (particularly as blowers for loading lines, with compression ratios of 1.5 ... to 2) and by the inversion of the drive, as gas meter counters (volumetric rate measurements). If a (normal) Roots blower is used as a "Rootspump" operating against atmospheric pressure, only ultimate pressures of about 450 mbar are obtained. The application of Roots pumps in vacuum tecnology applications was only rediscovered in about 1954, by introducing certain constructional modifications.

The PNEUROP–standard (and DIN 28426) defines a Roots pump as follows:

"Roots pumps are rotary plunger type pumps where two symmetrically shaped rotary pistons rotate inside the pump housing. Each of the pistons has 2 or 3 lobes, which rotate without intimate contact in opposite directions. They are synchronized so that they slide past each other and the pump housing in close proximity. That construction permits pressures lower than 1 mbar to be achieved *when operated together with a suitable (fore vacuum) primary vacuum pump*".

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5.4.1 Principle of operation

In vacuum technological applications, Roots pumps are provided with two lobed rotors. Their operating principle is seen from fig. 5.37. Two figure-of-eight shaped rotors move in opposite directions inside a housing. Their movement is closely coupled with equal-toothed gear wheels to ensure an interrolling of the pistons so that they are near to one another and to the housing without actual contact. The gap between the pistons and towards the housing without actual contact. The gap between the pistons and towards the housing is kept as small as possible. It depends on the size of the pump and the desired pumping efficiency as well as the actual application of the pump. The specific gaps are a compromise, usually of the order of around 0.1 mm.

To simplify the diagram and explain the operation of the pump, consider only the right side of the pump in fig. 5.37. In the piston position I and II, the volume in the pump towards the chamber to be evacuated is increasing. In position III the crescent shaped volume is closed-off from the inlet side of the pump. On further rotation, this volume is opened to the pump outlet, the pressure side (primary vacuum side) and the gas at fore-vacuum pressure p_V streams into the previously closed-off space (piston position IV). The incoming gas compresses the gas already there and both are expelled together with the gas previously transported from the inlet; after further rotation of the piston the gases are expelled. The volume of gas transferred is therefore (ignoring the losses) the volume V_2 of the crescent shaped space in position III. Because this volume is created twice with every complete rotation, and because there are two pistons (at the left side of the pump, the volume V_2 is created also twice with each rotation), the volumetric displacement (corresponding to the swept volume of the rotary plunger pump) of the Roots pump is given by: (5.51)

$$V_S = 4 \cdot V_2 .$$

Using high rotational speeds (e.g. $n = 3000\ \text{min}^{-1} = 50\ \text{s}^{-1}$) small and medium size pumps will produce relatively large pumping speeds $S_{th} = n \cdot V_S$. S_{th} is the theoretical pumping speed. The actually obtainable pumping speed is lower due to inherent losses (see for example table 5.3, last but one column). The rotational speeds which can be used are limited by the rotor material employed in view of the centrifugal forces created.

The pump operates in its housing in a completely dry state, it is only the bearings and toothed drive wheels which are supplied with oil for their lubrication. Between the pump

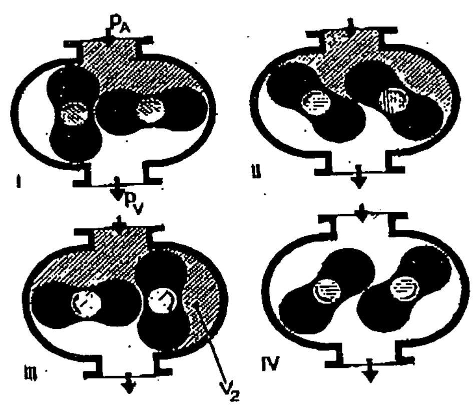

Fig. 5.37
Pump phases I to IV of a Roots pump. Right hand rotor rotates clockwise, left hand rotor anti-clockwise.